- *Web Server:*
  A web server can best be described as a computer that is connected to the Internet. This computer acts as a storage device for documents and files. Information can be in the form of audio, video, graphics, or text and is displayed or provided when Internet users access or request information. Web service providers lease space within the computer or web server for individuals wanting a web page. Web service providers can also be ISPs.

- *Router:*
  In the global computer network of the Internet, a router is used to direct or route data packets through and between multiple networks. Routers are located in areas where multiple networks or segments of networks interconnect or meet. The router is a digital switch that has the capabilities of handling packets of data. The switch is often called a packet switch. When packets of data enter the switch, the switch has the capability of reading destination information contained in the header on each data packet. Once the destination of the data packet is known, intelligence (software) within the router provides routing information on the packet's destination to the switch. The switch passes the packet of data to the appropriate network facility. The switch also uses network monitoring information to pass the packets to alternate routes with less traffic or less congestion. Information or data flowing through the Internet will use many routers between origination and destination points.

  There are two basic types of routers: core routers and edge (or border) routers. An individual NSP will have core routers that only pass packets within its own network. The NSP will also have edge routers whose major role is to connect the NSP's network to other service providers. These routers can be seen as entry and exit points for the packets of data. Edge routers are usually not involved in the running of any network layers.

What are some general customer routes to the Internet?

Transporting information on the Internet does not require a dedicated point-to-point transmission path like telephone voice communications. Packets are passed from router to router to the desired destination point. Software within Internet routers determines how and when the packets of information traverse the networks.

Packet flow through the Internet could be compared to having three sets of train tracks between Seattle and Miami. The three routes could be identified as the northern route, the central route, and the southern route. A single train with many cars, each sequentially numbered from the front to the rear of the train, would be sent from Seattle to Miami. Some of the cars would go on the northern route, some on the central route, and the remainder being sent along the southern route. In Miami, the train cars would be sorted in the order of origination and exit on a single track. Any returning cars would not necessarily follow the same routes back. In addition, multiple trains may use these tracks at the same time.

Routes through packet-switched networks are different from routes through circuit-switched networks. To continue with the train route analogy, circuit-switched routes only go back and forth on one set of tracks between the two cities. The difference is that there is a dedicated connection between the two points.

Figures 3 through 6 provide simple diagrams of some general customer routes to the Internet through traditional voice, data, and video services. There are four general types of access to the Internet or to an ISP by a customer. The first is through the PSTN using dial-up access **(Figure 3)**. The second is through a dedicated private line, which may or may not use PSTN facilities **(Figure 4)**. The third route **(Figure 5)** shows customer access to the Internet through a cable TV company. The fourth route **(Figure 6)** illustrates satellite links to provide customers access to the Internet. The descriptions of these four types of customer access to the Internet are as follows:

- *Dial-up access:*
  This is the most common and least expensive form of individual access to the Internet **(Figure 3)**. Most customers with personal computers, modems, and Internet software use this type of access. In many locations, customers can gain access to their selected ISP by dialing a local telephone number. The physical connection between the customer and an ISP involves the use of telephone facilities consisting of two local loops and a telephone switch. One local loop is from the customer to the telephone switch and the other local loop is from the switch to the ISP. To connect to the ISP, the customer dials the ISP's telephone number. The call is processed through the ILEC/CLEC switch and sent to the ISP. Modems in the customer's computer and in the ISP facility (the modem bank) convert computer signals to analog signals on the voice-circuit local loop and back to digital signals that are needed for computer-to computer information exchange.[5] After logging onto the ISP system, the customer is ready to journey through the multiple networks of the Internet.

- *Dedicated private line access:*
  This type of access uses a dedicated private line **(Figure 4)**. Generally, the customer has a large volume of traffic and uses a private network for computer data — a local area network (LAN) or intranet. The customer leases facilities or services from a local telephone company (or other entity) to obtain a continuous permanent connection to the ISP facilities. This physical connection can be provided by many different technologies. A typical configuration can consist of a physical cable pair and an electronic circuit or multiple circuits, depending upon the needs of the customer. The private line may pass through the local service providers switching facilities or may circumvent them. By definition, private line services are not switched.[6]

  By selecting one service over another, a customer either uses the ILEC/CLEC switch or circumvents this switch through the use of leased facilities. Generally speaking, dedicated private line connections provide digital transmission capabilities and avoid the need for analog conversions. This type of connection eliminates the need for the modems illustrated in **Figure 3** and may also eliminate the need for the LEC switch. In a nutshell, dedicated private lines are always active, or "up", between the ISP and the customer. In this case, access to the Internet depends on ISP security and system controls.

Figure 3: General Route from the Public Switched Telephone Network (PSTN) to the Internet — Circuit-Switched to Packet-Switched

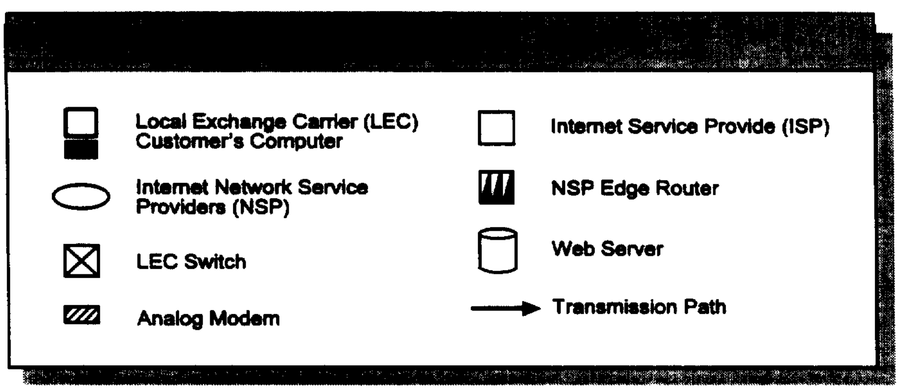


Figure 4: Local Area Network (LAN) Route to the Internet — Packet-Switched

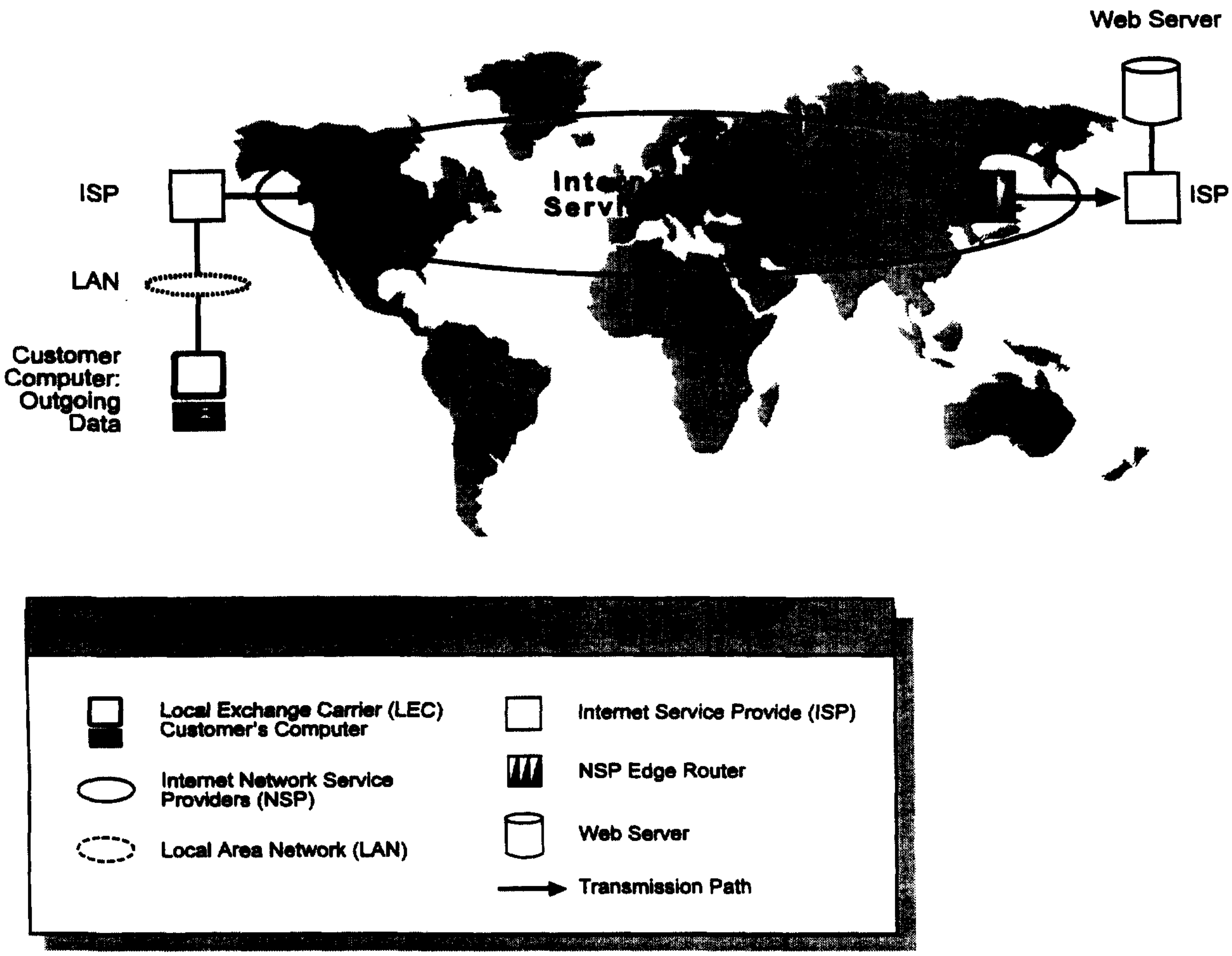


Figure 5: Cable Modem Route to the Internet — Packet-Switched

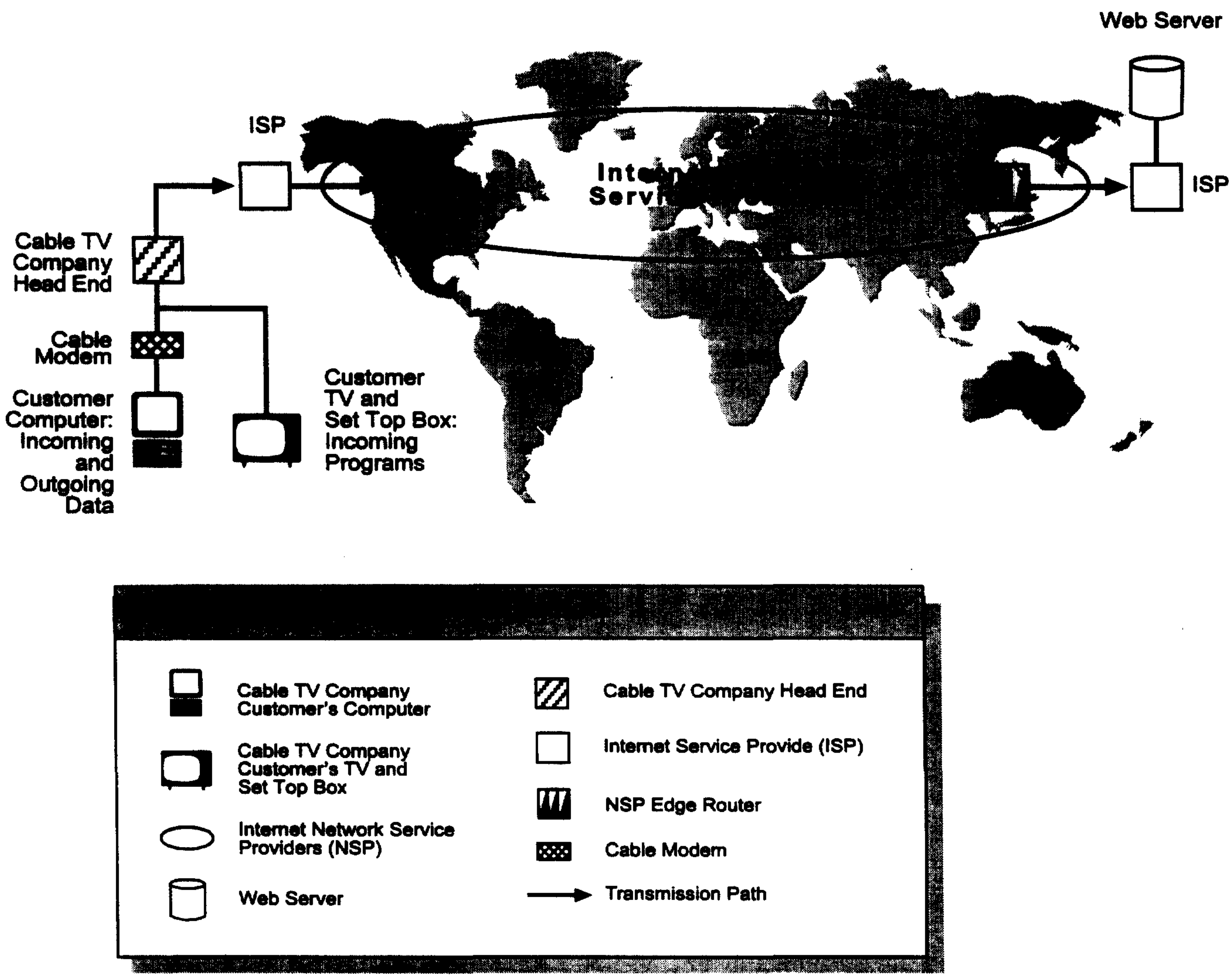
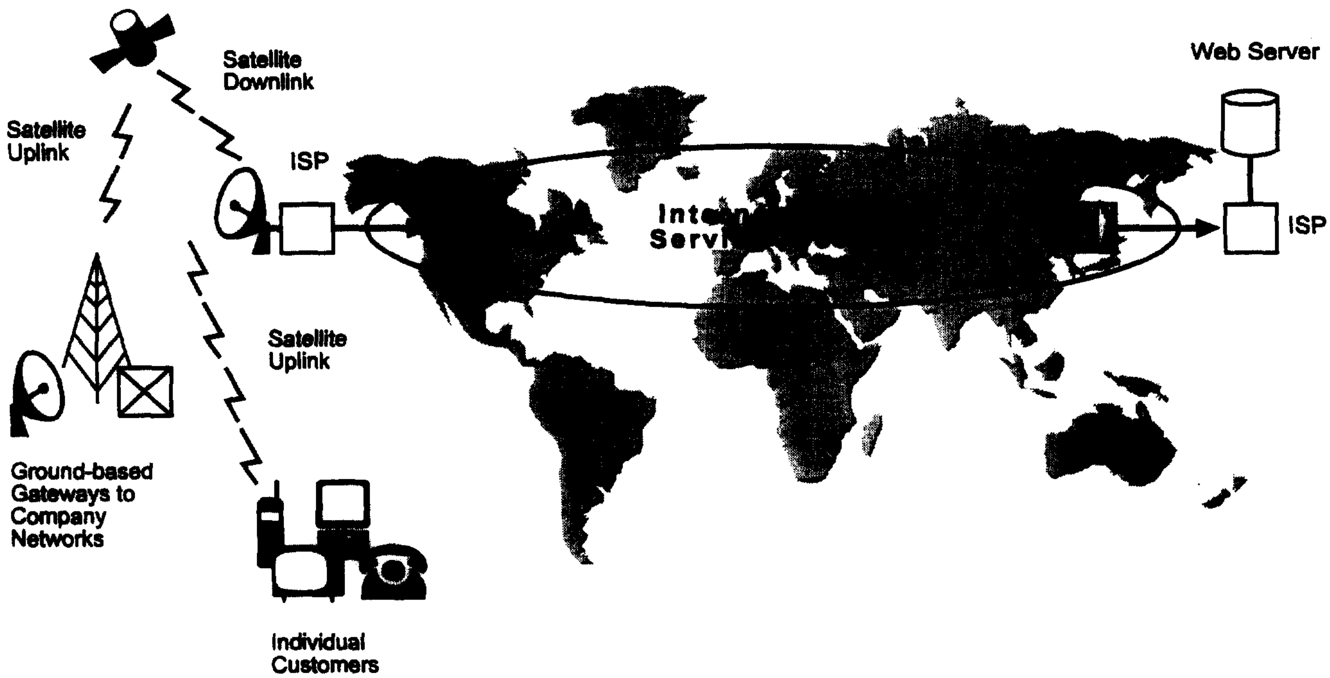
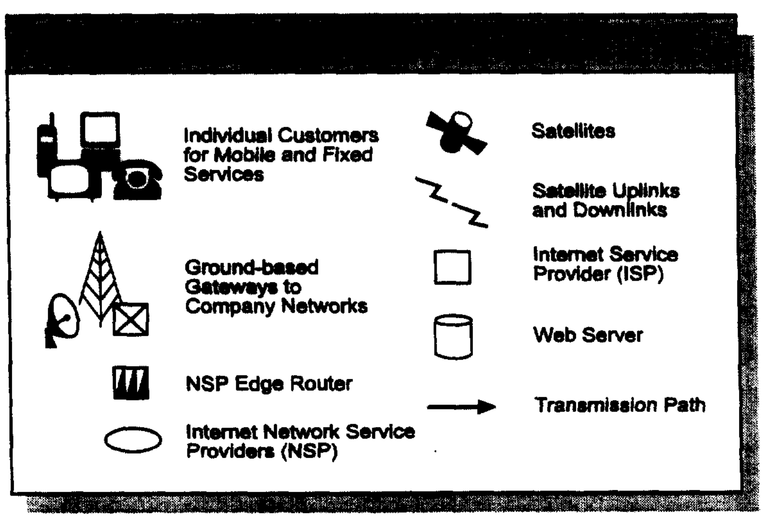


Figure 6: Satellite Routes to the Internet — Packet-Switched





- *Cable TV access:*
  Figure 5 shows a customer with both cable TV[7] and a computer with Internet access. TV channels provided over the cable system may involve the transmission of analog signals, digital signals, or a combination of both types from the "head end" of the cable system to the customer location. The transmission of the TV channels to the customer is one-way, or "downstream," from the satellite receiving equipment at the head end.

  Computer access to the Internet is accomplished by using a cable modem as part of the transmission path. The cable modem secures a small portion of the bandwidth for receiving and sending data to the head end facilities of the cable TV system.[8] Signals from the cable modem are sent and received at the head end by a Cable Modem Termination System (CMTS). The CMTS converts the data signals to an Internet protocol and passes the data to the ISP and the Internet. In some situations, the cable operator may also be an ISP.

- *Satellite access:*
  Figure 6 illustrates that there are many different services that may use satellite links to connect to the Internet. While this figure only shows one direction — routes from the customer or company gateways to the Internet, signals may also travel back depending on the type of service. The satellite links ground-based networks or customers to the Internet. The customers may be mobile (move over the earth, such as cellular customers or ships at sea) or may be fixed (stationary). Gateways link company networks to the ISP.

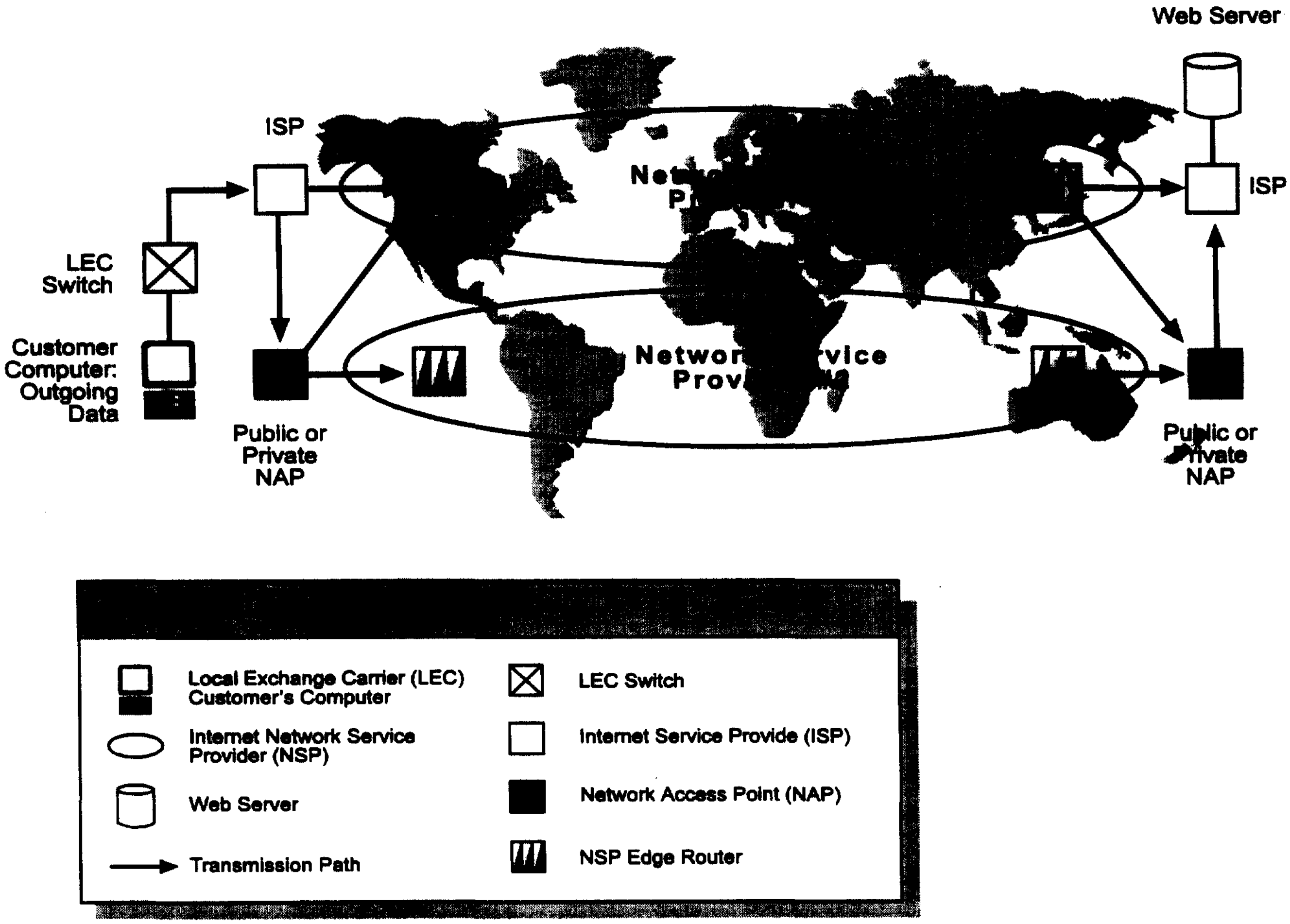
How do ISPs connect to the Internet?

While **Figures 3 through 6** focus on customer connections to ISPs, the next question that follows is: How do these ISPs connect to one of the NSPs that make up the Internet backbone? **Figure 7** illustrates these connections.

ISPs typically connect to an NSP by use of an Internet gateway. A customer's Internet query is in the form of data packets.[9] This request is forwarded by the ISP to the NSP's network. In certain situations, the data packets travel over the NSP's network out to a second ISP that connects to a web server containing the desired information. In other situations, the NSP has a direct connection to the web server. The requested information is assembled in packets and then routed back to the customer. It important to note than an ISP may also be an NSP.

The exchange of traffic between Internet companies is provided through a "peering arrangement." These contractual arrangements allow an ISP to connect its customers to one of the many NSPs that make up the Internet. Peering arrangements also exist between NSPs. The original peering arrangements allowed the ISPs and NSPs to accept and hand off traffic to each other with no charge. In these cases, the traffic volumes exchanged between participants were about equal. Some of these peering arrangements are still in place. In the current environment, when the traffic is not balanced between two parties, a contractual arrangement is often used to [redacted]

Figure 7: Path of Internet Transmission — Peering Arrangements and Network Access Points (NAPs)



Companies need peering arrangements to pass or exchange traffic. Both NSPs and ISPs have the option of whether or not to have a peering arrangement with a particular ISP or NSP. This option is a major difference from the traditional telephone network (the PSTN), where regulations require standard interconnection. Furthermore, the ISP may need to route its packets through more than one NSP to reach a specific web server.

In addition, NAPs provide connection points for multiple service providers, both NSPs and ISPs. These NAPs may be either public or private. However, most traffic is exchanged outside the NAPs. The actual network arrangements are far more complicated than those illustrated in **Figure 7**.

IV. Network Convergence — Current Examples

What is Network Convergence?

Connections between different types of networks are driving the policy issues raised by the questions in **Section II** of this paper. This includes connections between packet-switched and circuit-switched networks, wireline and wireless networks, and regulated and unregulated networks. In addition, a network component can be used to offer many different types of service. For example, the local loop can be used for a variety of services — voice calls, Internet access, and alarm systems.

Are the varieties of services that are being deployed meeting the Section 706 definition of advanced telecommunications capabilities? Are the networks at least moving toward this goal? Where network convergence is taking place, are changes in policy needed to accommodate the blending of technologies? To answer these questions, it is necessary to know current network points of convergence. This section covers some current examples where the circuit-switched and packet-switched networks already connect.

The examples in this section **(Figures 8 through 13)** illustrate that network convergence is a step-by-step process.[10] They show current network evolution for various industries. Many of the central networks (such as the IXC transport systems, the ILEC/CLEC connections between switches, and the Internet backbone) are already digital fiber optic networks. Technologies that allow both circuit-switched and packet-switched signals to travel on the same path to the customer are part of this convergence. Simply put, the trend is to push the packet-switched network closer to homes and offices. Commonplace examples already in use are computer modems and cable modems.

This convergence is part of an evolutionary process. Some technologies will lead to dead ends; others will become the new standards. The speed of replacement of one technology with another depends on a number of factors, which include the following:

- *Markets:*
  Is there demand for services that will use these technologies? If not, does the company want to take on the risk associated with an investment for which demand must be developed?
- *Existing facilities:*
  Can the new technologies improve on the capabilities and/or cost of existing facilities? Are the existing facilities in good physical condition or are they ready to be replaced?
- *Maturity of the technology:*
  Is the technology still under development? Generally, technology costs are high in the early stages of development. On the other hand, if a technology is mature, it may be too late to deploy it since newer technologies may be better.

IV. Network Convergence — Current Examples, cont.

What is the current status of network convergence?

Figures 8 through 13 show current examples of network convergence of circuit-switched and packet-switched technologies. While these examples are some of the most common configurations for voice, data, and video services many other technologies and configurations are possible. As these figures illustrate, for some companies, some portions of their networks already interweave circuit and packet technologies. In **Figures 8 through 13**, this convergence is highlighted by a gray screen.

What were the traditional voice, data, and video networks?

Historically, the telephone network carried public voice communications, private corporate networks delivered data, and broadcast networks delivered video. Each of these services was coupled with a specific form of infrastructure, such as copper pairs for telephone or coaxial for cable TV. Digitalization of voice, data, and video information has become a standard practice. This practice has allowed traditional boundaries to be crossed relative to services being provided. In other words, a single facility carriers voice, data, and video. A good example is the provision of voice communications on a cable TV company's coaxial cable. With digitalization of information, the network needed for transport only requires digital transmission capabilities. Legacy networks designed for specific technologies are in the process of transformation to allow provision of all types of services.

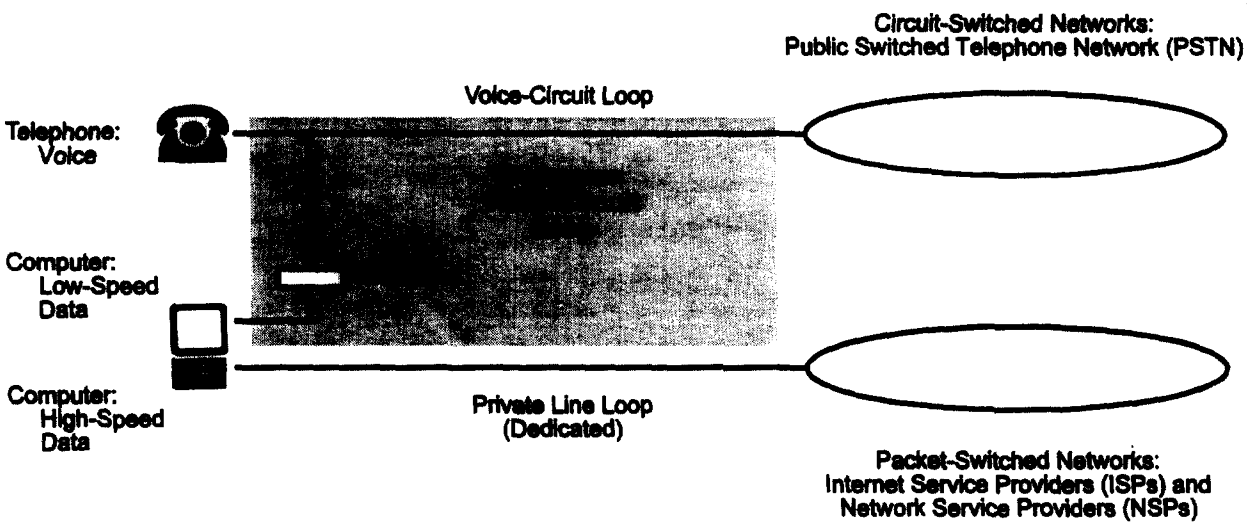
Where are voice and data networks converging in the traditional telephone industry?

Traditional voice communications networks have evolved, with the use of modems, to provide low-speed data over analog voice loops. **Figure 8** is a diagram of the convergence of voice and data networks in the traditional telephone industry. A typical household is connected to the PSTN using a voice-circuit loop. This path represents the traditional telephone route to circuit-switched networks. **Figure 8** also shows the use of a dedicated private line loop to enter the packet-switched network. This path represents the traditional data route to packet-switched networks.

The major difference between these two types of loops is that the voice loop is provided to the customer as an analog circuit. The private line loop, on the other hand, is a direct connection to the customer's ISP and is continuously "up" to transmit data between the customer and the ISP. If private line facilities are provided to the customer on a standard copper loop, transmission capabilities, or bandwidth, are limited to the capabilities of a voice-circuit design inherent with the local loop.[11]

IV. Network Convergence — Current Examples, cont.

Figure 8: Converging Voice and Data Networks — Traditional Telephone Industry



IV. Network Convergence — Current Examples, cont.

Figure 8 illustrates current network convergence that allows households and other low-volume customers to transmit data over the voice-circuit loop. Low-speed data over the traditional voice-circuit loop makes it possible for these customers to access packet-switched networks such as the Internet. In **Figure 8**, the voice traffic connects to the circuit-switched PSTN. The low-speed data traffic is sent through the same voice-circuit loop. While not illustrated in the figure, this low-speed is carried over a voice-circuit loop to an ISP that is connected with the packet-switched Internet. The high-speed data traffic is sent directly to the packet-switched network.

Where are voice and data networks converging in the wireless industry?

In **Figure 9** a computer connects to the Internet through a wireless handset. Unlike **Figure 8**, no modem is required between the handset and the computer because this is a digital system. A cable plugs into a jack in the handset in a similar fashion as the traditional telephone cord into a household telephone outlet. In a digital wireless network, both voice and data are carried digitally to the wireless company switch. Voice traffic is routed to the PSTN and the data traffic is routed to an ISP. The wireless digital network supports multiple data services. These include two-way, short messaging service, circuit-switched data services, and packet-switched data services. Software performs the conversions from wireless protocols to Internet protocols. The Short Messaging Service Center (SMSC) converts paging and other types of short messages. The Inter-Working Function (IWF) converts cellular and PCS protocols.

If the wireless handset uses an analog transmission instead of the digital transmission illustrated in **Figure 9**, then the computer, typically a laptop, needs a modem for the connection.

Where are video, data, and voice networks converging in the cable TV industry?

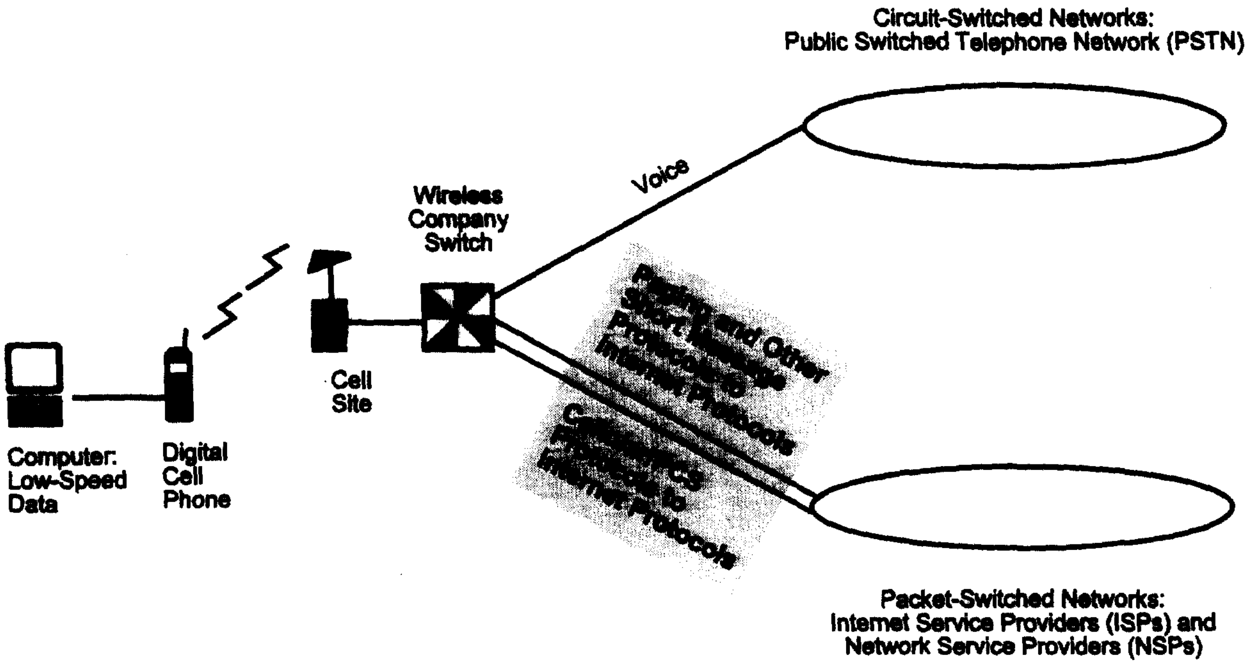
In the United States, there are two basic network designs for cable TV systems. One type has outside facilities that consist entirely of coaxial cable and the other type has a mixture of fiber-optic cable and coaxial cable, called hybrid-fiber coax (HFC). Signals in these systems can be either in analog format or in digital format.

Cable TV systems can also be classified by whether the transmissions are one-way or two-way. In one-way systems, transmission paths for services are from the head end facilities to the customer (downstream only). In two-way systems, the transmission paths are to the customer (downstream) and to head end (upstream) facilities. HFC systems are digital and generally two-way. HFC systems are being modified to provide voice, data, and video services. With these systems the return-path fiber links (upstream), to the head end facilities, are included.

Figure 10 shows converging video, data, and voice services in the cable TV industry. TV channels are provided through the set top box, which acts as a tuner and demodulator for digital/analog TV services (video). Data is sent and received by a computer using a cable modem to access the Internet. The data is packet-switched. All three types of services (video, data, and voice) are routed through a network interface unit (NIU) at the customer's location. The NIU contains electronics that convert analog voice to digital format.

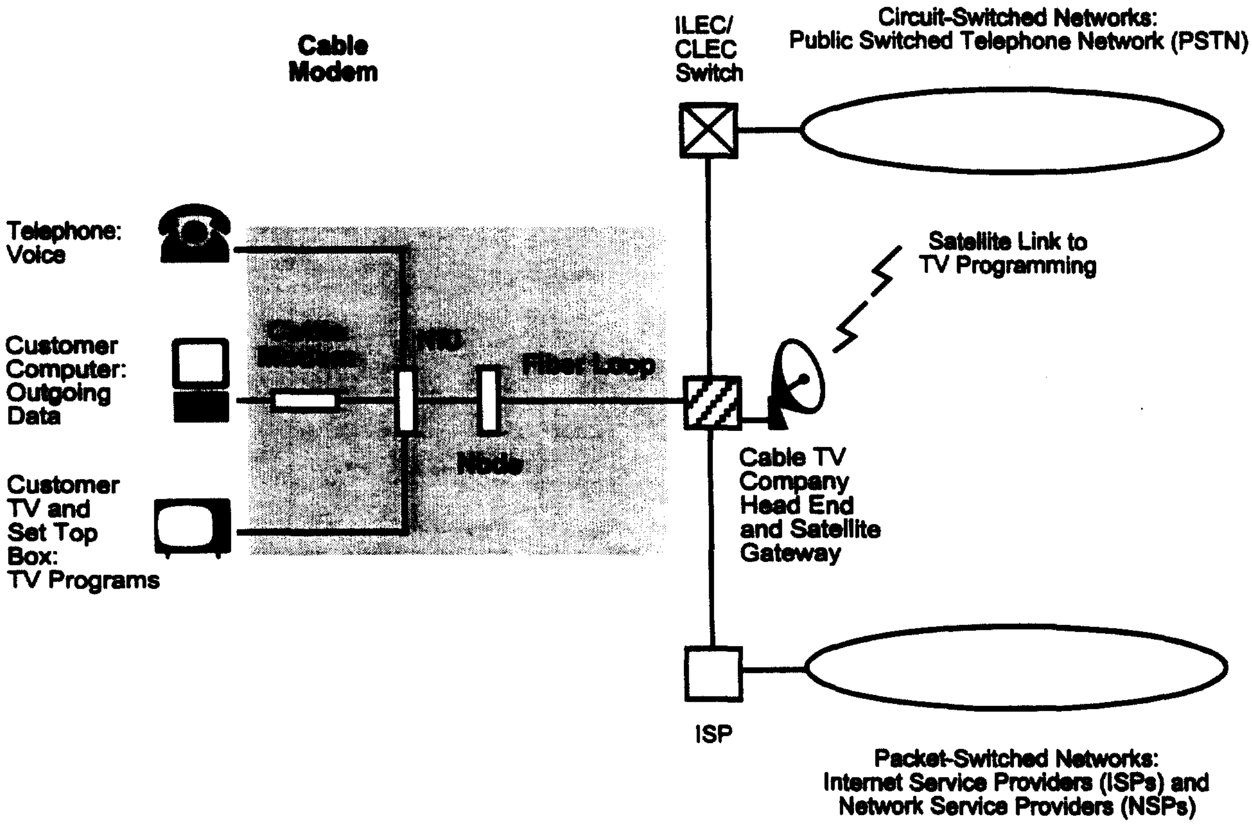
IV. Network Convergence — Current Examples, cont.

Figure 9: Converging Voice and Data Networks — Wireless Industry



IV. Network Convergence — Current Examples, cont.

Figure 10: Converging Video, Data, and Voice Networks — Cable TV Industry



CLEC Competitive Local Exchange Carrier
ILEC Incumbent Local Exchange Carrier
NIU Network Interface Unit

Coaxial facilities link the NIU at the customer's location to a cable system node. Cable system nodes use a serving area concept. In other words, a single node could provide service for as many as 1,000 homes. The node acts as a funnel for consolidating digital voice, data and video signals from all the attached customers. A fiber-optic pipe transports these signals to the cable TV company's head end, where each service is passed on to the appropriate network.

At the head end, a cable modem terminating system (CMTS) converts digital signals into the Internet Protocol (IP) and back. The next step in the route is the ISP which, in turn, connects to the Internet. The cable TV company may also be this ISP.

The head end also receives video programming from satellite gateways using a satellite dish. Generally these signals are downstream (to the customers) with the exception of requests for services such as "pay per view." Several organizations have provided trials on what is called "Full Service Networks" (FSN). FSNs include video on demand type services.

The cable TV company's head end routes the voice signal to a telephone head end unit which formats this signal for telephone switching (circuit-switched). The voice signal is then routed to the party on the receiving end. If the call is sent to a local telephone company customer, then the call is routed to an ILEC or CLEC switch that connects to the traditional telephone networks, the PSTN. If the call is sent to another local customer using the same cable TV company's voice service, then the call (digital voice) is routed back through the cable TV system. In an effort to provide long distance telephone service, cable companies are exploring interconnecting multiple cable TV voice networks. The voice traffic may also be handled through the IP network, and in most cases will involve both packet-switched networks and circuit-switched networks.

What is the relationship between xDSL technology and network convergence?

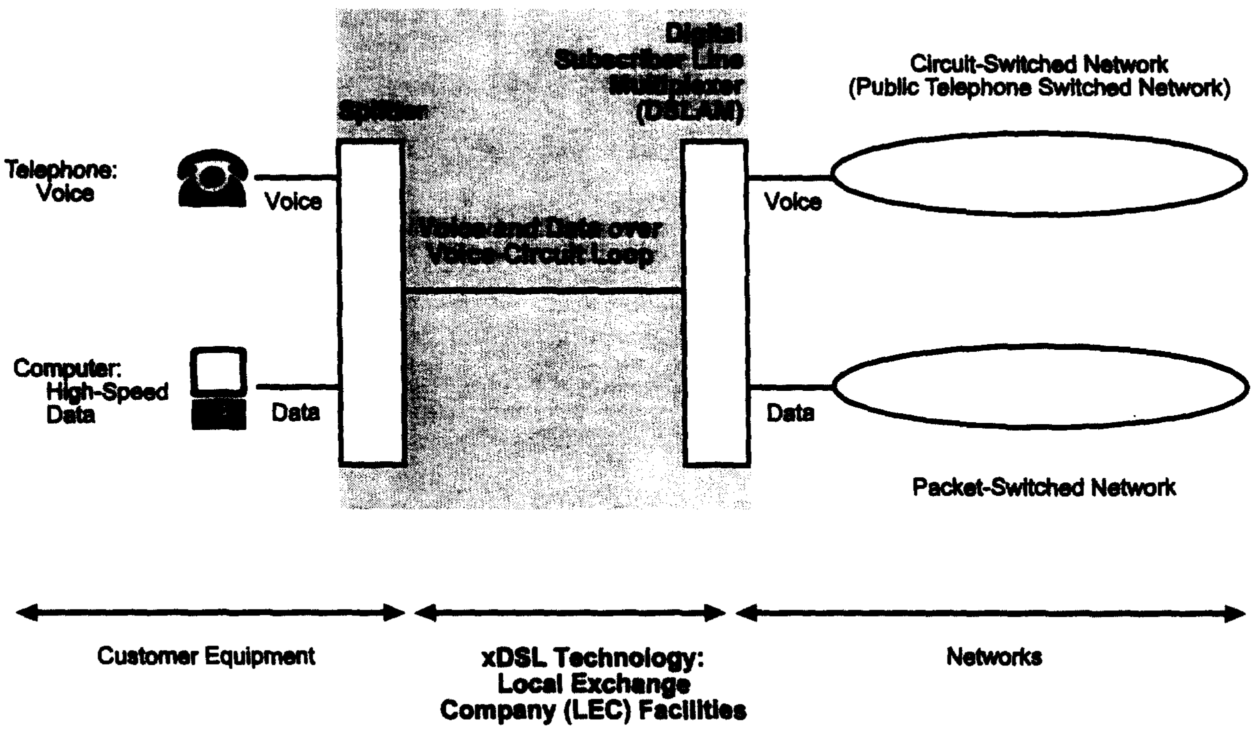
Figure 11 illustrates one step to network convergence beyond that shown in **Figure 8.** As customer demand for high-speed services such as the Internet has increased, local telephone service providers began to see the limitations of systems designed primarily for voice communications. Solutions have been developed and introduced in an attempt to roll out new technologies and to meet customer needs.

A family of technologies known as "digital subscriber line," or xDSL technologies, is being developed to allow higher bandwidth services to be delivered over the existing copper loop. These new technologies use the existing copper local loop to provide both voice and data services. The xDSL technologies are seen as one step toward meeting customer demand for high-speed access in a faster and less costly manner. These new technologies are now being deployed. For a summary of xDSL technologies, see **Section VI, Appendix A.**

Figure 11 is a diagram of a typical xDSL technology. At the customer's location, the telephone and computer are connected to equipment called a "splitter," which is a special type of modem. The splitter combines voice and data for transmission over the local loop. Transmission of voice and data over the local loop is completed using analog frequencies with voice being in the lower frequencies and data being in the higher frequencies.

IV. Network Convergence — Current Examples, cont.

**Figure 11: One Step to Network Convergence —
The Family of Digital Subscriber Line Technologies (xDSL)**



A Digital Subscriber Line Multiplexer (DSLAM) is located on the other end of the local loop. The DSLAM separates voice and data onto two different paths. Voice communications are passed to the PSTN and data communications are converted to digital packets and then passed to packet-switched networks. The DSLAM also acts as a funnel to interweave data from multiple users into a condensed format for packet transport to the networks. 564 DSLAM data paths can be funneled into one high capacity transport pipe with a capacity of 45 megabits per second (mbps).

How are satellite voice and data networks converging?

Figure 12 shows one example of satellite convergence of video, data, and voice networks by satellite service. One direct broadcast satellite service (DBS) allows customers to subscribe to video programs (TV programming) and to Internet services using satellite technology. The customer has the choice of either service or both. The DBS service company sends video and high-speed data to the customer through a ground-based gateway that sends the signals through an over-the-air uplink to the satellite. The satellite passes these transmissions on to individual customers through an over-the-air downlink. If the customer subscribes to an Internet service, low-speed data responses are sent back to the Internet through a modem attached to a traditional telephone company voice-circuit loop, through the PSTN, and on to an ISP.

Satellite technology can also be linked to mobile customer equipment as well. Therefore, **Figure 12** is one possible path for network convergence. Other satellite systems link services through gateways to customers with both uplinks and downlinks. Communications may be one-way or two-way.

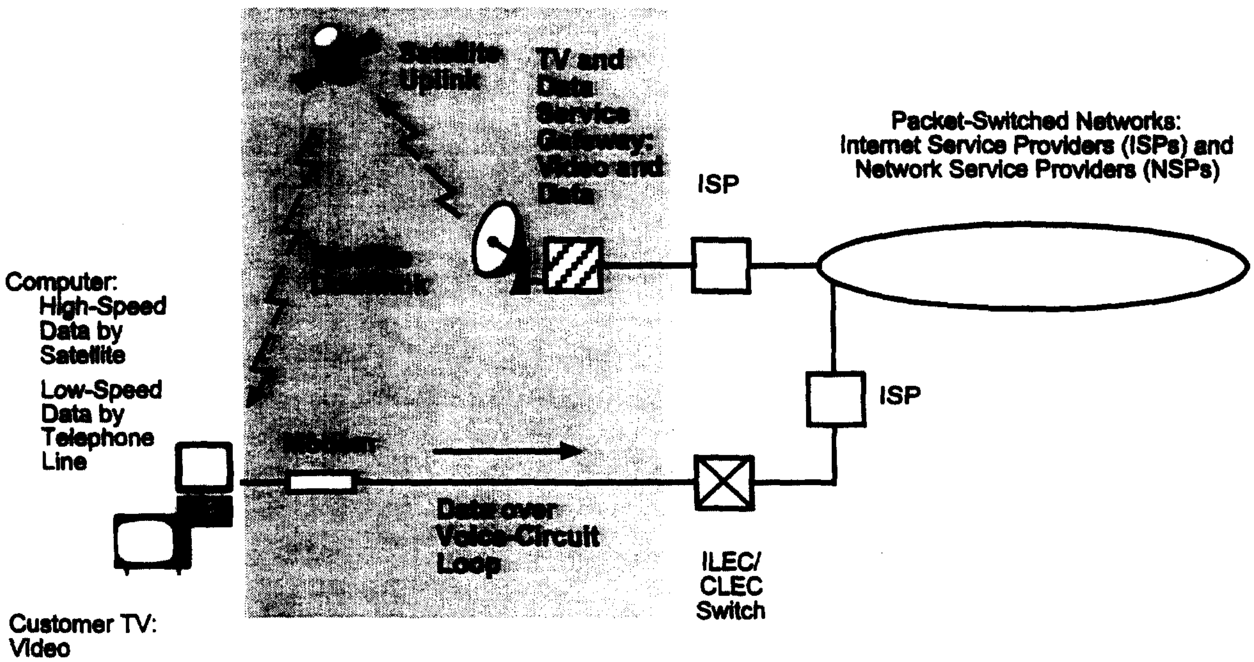
What is the relationship between fiber technology and network convergence?

Fiber-to-the-curb (FTTC) is a technology that brings the path for high-speed data and voice closer to the customer. FTTC basically places high capacity facilities closer to the customer using fiber optics and coaxial cables.

Figure 13 illustrates FTTC technology. For short distances the link between the fiber loop and the customer's household wiring (the drop) may be either twisted copper wire pair or coaxial cable. Voice-grade analog communications are provided to the customer on twisted copper pairs from the optical network unit (ONU). Cable TV and data services are provided on coaxial cable between the ONU and the customer. The television and the computer are connected to a combination signal splitter and modem. TV programs (video) and computer data transfer functions are separated into specified spectrum ranges within the coaxial cable. Both the TV set top box and computer have receive and transmit capabilities. Television transmission capabilities are limited to provide services such as "pay-for-view" or broadcast video.

IV. Network Convergence — Current Examples, cont.

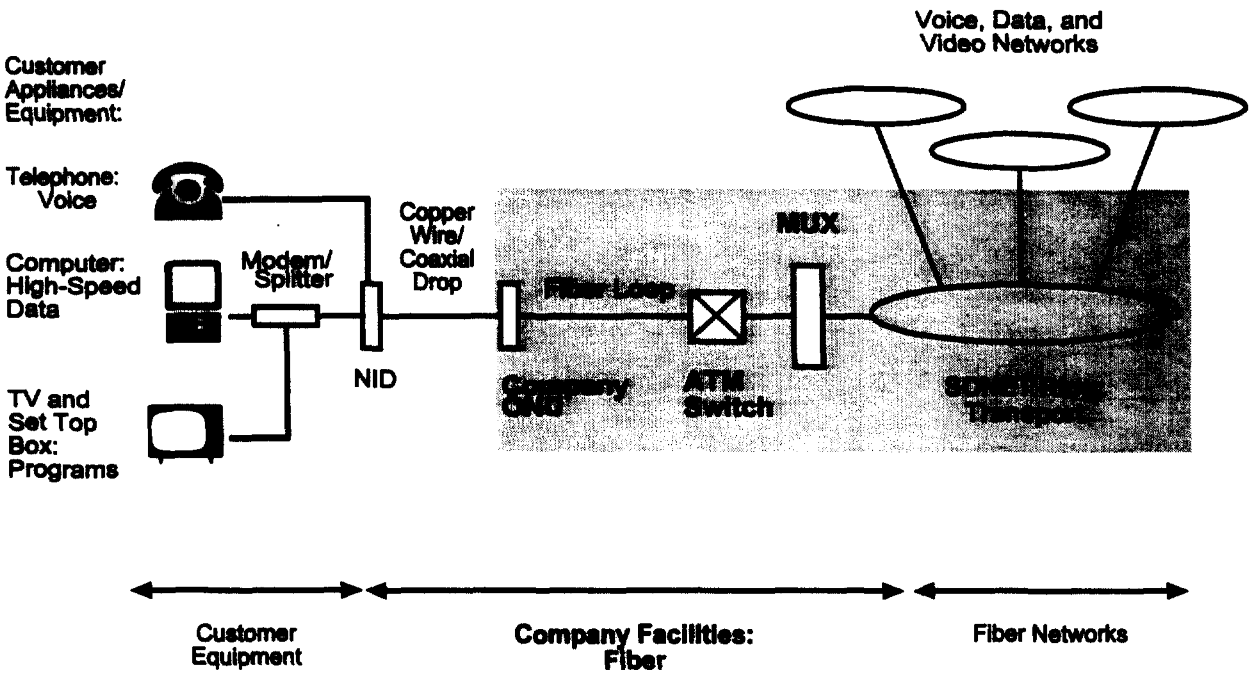
Figure 12: Converging Video, Data, and Voice Networks: One Satellite Industry Example — Direct Broadcast Satellite (DBS)



CLEC Competitive Local Exchange Carrier
ILEC Incumbent Local Exchange Carrier

IV. Network Convergence — Current Examples, cont.

Figure 13: Converging Voice, Data, and Video Networks: Fiber to the Curb (FTTC)



ATM Asynchronous Transport Mode
MUX Multiplexer
NID Network Interface Unit
ONU Optical Network Unit
SONET Synchronous Optical Network Elements for Transport

IV. Network Convergence — Current Examples, cont.

A company-owned network interface device (NID) links the customer's inside wiring and the company's network. In addition to serving as a point of connection, the NID also performs the function of grounding against lightening strikes and stray voltage.

In **Figure 13** voice-circuit (twisted copper pairs) physical connections are separate from the coaxial connection at the ONU. Analog voice communications are digitized and combined with computer data and TV video from all customers served by the ONU.

At the ONU the digital signals are converted to an optical signal format. The optical signals are passed through a fiber optic route to an optical receiver. This receiver converts the information to a digital format and then passes this information to the Asynchronous Transfer Mode (ATM) switch.

At the ATM switch, digital computer data, voice and television information transmitted over the fiber optics are separated into distinct groupings for each type of service. The separated information is then passed to the multiplexer (MUX)[12] with separate routes for computer data, voice and television. Digital information from other ONUs is also processed in the same manner. Once the voice digital packets reach the MUX, packets are funneled into a condensed data stream and passed to the Synchronous Optical Network Elements for Transport (SONET). This process also takes place for digital data and television information packets. Condensed or consolidated information on the SONET ring or network is transported to a desired location or vendor.

What is the difference between synchronous and asynchronous transmissions?

Methods of digital data transfer/transmission in a network can be separated into two classifications of synchronous and asynchronous.

- *Synchronous* transmission has characters, events, or bits spaced by time or by using a clocking signal. This means there is a constant time between successive bits, characters or events.
- *Asynchronous* transmission uses start and stop codes or bits for each character, event or segment of data transmitted. Since start and stop bits or codes are added to information that is asynchronously transmitted, transmission times can be greater than that of synchronous transmission.

Conventional networks carry data in a synchronous manner. Because empty time slots are circulating even when the link is not needed, network capacity is wasted. ATM technology automatically adjusts the network capacity by filling empty slots to meet the system needs.[13] ATM technology is compatible with SONET.

SONET is a family of fiber-optic transmission rates that range from 51.84 mbps to 13.22 gbps.[14] SONET optical-interface standards allow different companies to tie their facilities together.[15] Both SONET and ATM technologies let the customer purchase segments of the bandwidth in a pipe instead of the entire pipe.[16]

V. Network Convergence — Different Viewpoints

What are the different views on the ability to reach the Internet through various routes?

While network evolution is part of a continual process, the actual deployment of new technologies in an existing network may not always be smooth. For example, not all customers can get onto the Internet in the same manner with the same technologies. Companies have different customer prices and connection points. The result is that there are different views on whether or not there is a technical issue associated with the ability of a customer to reach the Internet through any given service.

This section discusses some of the major areas where there are different viewpoints on the ability of customers to reach the Internet through various services.

What constitutes congestion?

There has always been congestion over networks as part of the evolutionary process. Congestion pushes the deployment of additional facilities. The introduction of data traffic over the PSTN has changed the following:

- *When and where?*
  Given the nature of Internet traffic, the patterns are not as predictable as with traditional telephone network traffic. There is less historical data for network planning. Also, since the Internet links many database locations with a simple click, there is no advance predictability where the database may be located and whose network needs to carry the data.

- *How Long?*
  The length of a session also affects congestion. For example, an Internet customer clicking on a database located on a distant web server does not know if the response will take a short second or hours of downloading information. Another example may occur when a customer uses dial-up access to the Internet. In this case, the individual customer ties up one of the ISP's modems for as long as the customer chooses to stay "on-line" regardless of whether or not data is transmitted. If no other modems are available at the ISP's modem bank, other customers dialing into this same ISP may get a "busy" signal.

- *How much?*
  The patterns of peak usage (full use of the network) are hard to predict on the Internet. In the traditional telephone industry, certain hours (business hours) and certain holidays (Mother's Day) are known to use the PSTN to its full capacity. On the other hand, the Internet times of peak usage vary (office lunch breaks, school homework assignments). Also, there is no advance predictability on the amount of information that will be downloaded in a given session. On the other end, a web server may not be designed to respond to all the information requests, called "hits," that it receives at a given time.

What is the impact of network design?

Various aspects of network design affect the availability and quality of a customer's connection to the Internet. Even when a connection is made, network design still determines the data transmission speed. The following list provides some network design factors that affect a customer's Internet services:

- *How does individual company network configurations affect the customer?*
  This may be a major factor in a customer's ability to reach the Internet from specific services. For example, a telephone company's loop may not be able to provide the required speed. While private lines are available, their installation and price may be a deterrent to most residential customers. Similarly, a wireless company may not have enough spectrum (bandwidth) to transmit data within a reasonable time frame.

- *How is the ISP's network configured?*
  The ISP may not have enough modem banks to accommodate all users. If an ISP leases facilities to an NSP or to a NAP, and those facilities are not sized to meet their traffic volume, then the traffic slows down. If the traffic volume exceeds the amount handled by a given connection, is there access to another network that will accommodate this overflow? In addition, are the public network access points capable of handling their traffic in a timely manner?

- *Does the network connect to the customer?*
  If not, then there's no service to cause congestion. For example, not every area has cellular service; not every household is hooked up to a cable TV line or has wireless service available (referred to as "homes passed").

- *Has the company allowed over-subscription of its services?*
  There may be problems resulting from too many customers for a given network. A company that oversubscribes customers to its services may not have the network capacity. This has occurred with ISPs.

- *Is the network designed for the appropriate session length?*
  Most of the PSTN was not designed for long holding times for each telephone call. In 1996, an average telephone call was five minutes and an average Internet session (connection) was 1 hour and 8 minutes[17]

- *Is the web server designed to meet the demand?*
  If the size and the speed of a web server are insufficient to meet demand, customers trying to access the website may experience delays in downloading data or will make multiple attempts to connection to the website.

- *What is the impact of the customer-owned equipment and software?*
  Customers make choices when they purchase their equipment on capabilities and quality. In other words, customer-owned equipment may be outdated or incapable of adequate transmission speeds. The same is true for software. Lack of knowledge or inexperience may also create problems for the customer.

What is the impact of network reliability?

Network reliability covers many aspects that boil down to "you get what you pay for." For example, it is possible to get a reliable Internet connection by purchasing or leasing a private line. However, this can be expensive. One method of avoiding network outages (the network goes down) is to purchase additional routes or to have a backup service provider. This is called "redundancy" and it too costs money. Furthermore, there is the question of how a customer values and pays for reliability in a multi-company, multi-network environment. For example, who is responsible when the crew digging up the street cuts through a cable TV or telephone line? Who provides service after a natural disaster?

What is the impact of bandwidth limitations?

The amount of bandwidth available to reach the Internet depends on the type of technology used by the customer. "Bandwidth" is the difference between the highest and lowest frequencies carried by a transmission medium.[18] The term "bandwidth" is often incorrectly used as a surrogate for bit rate. This is the amount of data that can be sent over a measured time period (generally, the number of bits per second). The maximum bit rate that may be sustained within a given bandwidth (frequency range) is limited by the power of the signal and the noise of the system.[19]

For a given transmission, the limits are determined by the minimum bandwidth of any segment of the route. The analogy is that a car may be able to travel at 120 mile per hour. However, if the car is in a 20 mile-per-hour speed zone, then no matter how souped up the car, its speed is restricted. Another way to look at the bandwidth issue is to see it as a "restricted speed" issue.

"Broadband" is a facility having a bandwidth, or capacity, of more than 1.544 megabits per second (mbps).[20] These facilities may carry numerous voice, video, and data channels simultaneously. "Narrowband" is a facility with a bandwidth of 56 kilobits per second (kbps) or less. This is the voice channel on the traditional telephone line. "Wideband" falls in between the two, with a bandwidth greater than 56 kbps and less than or equal to 1.544 mbps.[21]

These terms are further complicated by the fact that for Personal Communications Services (PCS), the term "broadband PCS" refers to a spectrum allocation for voice services and the term "narrowband PCS" refers to a spectrum allocation for paging services. The next generation of mobile wireless networks may be limited by the availability of spectrum. For example, a service that needs new spectrum or increased bandwidth may not be able to obtain a license for this spectrum.

Cable TV systems also have bandwidth limitations. A typical analog cable TV coaxial system requires 6 megahertz (MHz) to carry one TV channel with the maximum capacity being achieved with 60 TV channels. Systems that are entirely coaxial cable can approach approximately 500 MHz of capacity. Digital systems require one to three MHz of capacity for each channel. HFC systems can approach one gigahertz (GHz) of capacity.

V. Network Convergence — Different Viewpoints, cont.

Are there separate networks or is it converging to one large network?

Each company has its own ideal network solutions. Some networks interconnect with one another; others don't. The reasons for these differences lie in customer demand, technical limitations, deployment costs, company policies, and regulatory requirements. Therefore, network convergence is an ongoing, evolutionary process. Long after the circuit-switched and packet-switched evolution is a distant memory, this issue will arise with the introduction of new technologies that go beyond current network capabilities.